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ROOST TREES USED BY PILEATED WOODPECKERS IN NORTHEASTERN OREGON

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Abstract: We wanted to identify the types of trees and habitat used by pileated woodpeckers (*Dryocopus pileatus*) for roosting, and to develop management guidelines to provide this habitat. Thus, we located 123 roost trees used by 22 pileated woodpeckers and observed their roosting behavior in northeastern Oregon, 1989–90. In all 443 instances, adult pileated woodpeckers roosted inside a cavity at night. The majority (62%) of the roosts were in grand fir (*Abies grandis*), both live and dead, that were extensively decayed by Indian paint fungus (*Echinodontium tinctorium*). The decay had created a hollow chamber inside the tree that averaged 4.3 m long (SE = 0.22) and 28 cm (0.29) wide where birds roosted. The majority of roosts occurred in old-growth stands of grand fir, with ≥60% canopy closure and little or no logging activity. Trees used for roosting and for nesting differed. Roost trees usually were live grand fir, were smaller in diameter, had more holes, and occurred lower on the slope than did nest trees. Roost habitat should be provided within 243-ha management areas for pileated woodpeckers and should retain old-growth stands of grand fir, large-diameter grand fir infected with Indian paint fungus, and large-diameter dead ponderosa pine in old-growth stands on mid- to upper slopes. Management agencies also should use the formula we developed to determine the number of roost trees to retain within each pileated woodpecker management area.

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The pileated woodpecker has been selected as a management indicator species for National Forests in the Pacific Northwest Region as part of the planning process in the National Forest Management Act. Because of its large size, the pileated woodpecker needs large, dead trees for nesting, and dead wood for foraging (Bull 1987). Large-diameter dead wood typically becomes scarce under intense forest management and declining rotation ages; therefore, the pileated woodpecker seems likely to be negatively affected by intensified timber management. To provide for future pileated woodpecker populations, the National Forests established pileated woodpecker management areas in mature and old-growth stands. Because only certain areas will be managed for pileated woodpecker populations, those areas must contain the habitat components critical to their survival.

Attributes of nest trees used by pileated woodpeckers are well documented (Hoyt 1957, Conner et al. 1975, McClelland 1977, Mellen 1987), but little is known about the trees used by pileateds when roosting at night and during inclement weather. It has been assumed that characteristics of nest and roost trees are similar (McClelland 1977, Thomas et al. 1979, Bull 1987) because pileated woodpeckers have been observed roosting in their vacated nest cavities (Lawrence 1970, McClelland 1977, Kilham 1979, Bull 1987, Mellen 1987). Whether nest trees and roost trees are similar is critical because nest trees are important for rearing young, and roost trees are used all year. Thus, our objectives were to determine what trees were used for roosting by pileated woodpeckers throughout the year, ascertain if nest and roost trees have similar characteristics, and develop guidelines for land managers to provide appropriate roost trees for pileated woodpeckers within management areas.

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STUDY AREA AND METHODS

We radio-tagged 27 adult pileated woodpeckers in 1989 and 9 nestlings in 1990 in 5 study areas. All study areas were in the Blue Mountains within 100 km of La Grande, Oregon (Union, Baker, and Umatilla counties). Each study area was 1,400–1,600 ha in size and between 1,000 and 2,000 m in elevation.

Mixed coniferous forests predominated in all

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study areas, with scattered grasslands comprising 4–14% of each area. Forest stands were classified into 3 types with a modified version of the plant series (ponderosa pine [*Pinus ponderosa*] series, Douglas-fir [*Pseudotsuga menziesii*] series, and grand fir series) described by Johnson and Simon (1987). We classified stands as ponderosa pine type if they contained predominantly (>90% of trees) or exclusively ponderosa pine. Stands in the Douglas-fir type usually consisted of a mixture of ponderosa pine and Douglas-fir. Stands in the grand fir type contained grand fir, Douglas-fir, western larch (*Larix occidentalis*), and lodgepole pine (*Pinus contorta*).

All the study areas had been logged in the past. We grouped stands into 3 classes of logging activity: (1) no logging or high-grade cuts; (2) clearcuts or shelterwood cuts; and (3) partial overstory removal. Stands in the latter group had 20–40% of their basal area removed within the last 20 years; these stands still had an uneven-aged distribution of trees but typically lacked large-diameter trees. The high-graded stands in category 1 had been logged 20–50 years ago, and only the valuable, large-diameter, seral tree species (e.g., ponderosa pine and western larch) were harvested (also called economic selective harvest, Wellner 1978). These stands usually were fully stocked, and large-diameter trees, particularly grand fir, were common.

Stands of trees in the study areas were predominantly uneven-aged, thereby making classification into successional stages difficult. We classified stands as "young" if 90% of the trees were <30 cm in diameter at breast height (dbh). We considered stands "old growth" if they contained >10 trees/ha that were >50 cm dbh in the grand fir type, and >8 trees/ha >50 cm dbh in the ponderosa pine and Douglas-fir types. Old-growth stands were multilayered and had ≥60% canopy closure. Stands that contained trees >30 cm dbh, but did not have any trees >50 cm dbh or did not have enough to qualify as old growth, were considered mature.

We captured 22 adult pileated woodpeckers at their nests in June or July; 5 were captured in roosts from July to December. Each woodpecker was equipped with an 11-g 2-stage transmitter attached with a backpack harness. We located each bird in a roost tree every 2 weeks either by following the bird to its roost, or by locating the bird after dark and marking the tree. Roosts were located from June 1989 to March 1990, or until the bird died or the transmitter failed. All transmitters but 2 were removed after March.

Nine juveniles were equipped with a 2-g transmitter glued onto the feathers of their backs 0–5 days before they left the nest. We located juveniles in the evening once a week, 2–5 weeks after fledging to ascertain if they were roosting in cavities.

We returned to roost trees during the day and recorded tree species and condition (live or dead); tree dbh and height; top condition (intact, forked, broken); evidence of an injury to the tree (e.g., lightning strike, scarring, frost crack, new central leader where an old one died, forked top); presence of conks (sporophores); and number, height, and exposure of holes. In a 0.4-ha circular plot immediately surrounding the roost tree, we characterized the landform (upper third of slope, middle third of slope, and lower third of slope); forest type; successional stage; logging activity; and canopy closure. Canopy closure was measured with a spherical densiometer (Strickler 1959). Four readings were taken in cardinal directions 3 m away from the base of each roost tree and averaged to determine a canopy closure reading.

Sixty roost trees were climbed to determine if the roost cavities had been excavated, or if they were hollow chambers caused by decay. We recorded inside diameter and depth of the chamber, outside diameter of the tree, sill width (thickness of shell surrounding the cavity), and entrance hole width and height for each roost cavity.

Statistical Analyses

We compared roost tree habitat with available habitat within each of the 5 study areas with a Chi-square goodness-of-fit test (Conover 1980). Available habitat was ascertained by mapping the forest type, successional stages, classes of logging activity, and canopy closure (<10%, 11–59%, and ≥60%) in each study area. We mapped each study area by extensively surveying stands, interpreting aerial photographs, using Burr's (1960) classification of forest types for 2 study areas, and using Landsat classification of canopy closure for 1 study area (Bull et al. 1988). We were unable to use Burr's classification or Landsat for the other study areas because data were unavailable. We combined some categories for the analysis because of small

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sample sizes. We compared grand fir with all other forest types, compared old growth with other successional stages, compared unlogged and high-graded stands with other logged stands, and compared canopy closures ≥60% with canopy closures <60%.

Nest trees were located within the 5 study areas in 1989 and 1990 with techniques described by Bull et al. (1990). Characteristics of nest trees were measured in the same manner as described for roost trees. We compared roost tree characteristics with nest tree characteristics using Chi-square analysis for categorical variables and t-tests for continuous variables. Significance was defined as $P < 0.05$.

RESULTS

Roost Trees

From June 1989 until March 1990, we found 443 roost locations of 22 adult pileated woodpeckers (12 females and 10 males) representing 123 different roost trees. An average of 7 roost trees were used by an individual bird over a 3- to 10-month period (range = 4–11). Some birds used the same roost for months while others changed every few weeks. The woodpeckers always roosted in a cavity at night; we never found an adult roosting on the outside of a tree. Usually only 1 bird roosted in a particular tree at night, but on 4 occasions we found both members of a pair in the same tree, and on 1 occasion we found a male and a juvenile in the same tree. The 2 birds entered the same tree through different holes, but they shared the same hollow chamber.

Roost trees were typically large-diameter live or dead trees with a hollow interior. Of the 60 roost trees climbed, 95% had a hollow interior created by decay rather than being excavated by the woodpeckers. The remaining 5% had excavated cavities. Forty-six percent of the roost trees were in live grand fir, 22% were in dead ponderosa pine, 15% were in dead grand fir, 13% were in dead western larch, 3% were in live western larch, and 1% were in dead Engelmann spruce (*Picea engelmannii*). Average dbh and height of roost trees were 71 cm and 22 m, respectively (Table 1).

Each roost tree had 1 to 16 entrance holes ($\bar{x}$ = 2.7) in the trunk that pileated woodpeckers had excavated to reach the hollow interior of the tree. Of 123 roost trees, 25 had only 1 entrance hole, and the remainder had 2 or more holes. Of 17 trees with only 1 hole, and where we could determine the tree was hollow, 53% had a broken-off top, so the birds could enter or exit the tree either through the entrance hole or the top. Of 96 trees with 2 or more holes, only 25% had broken tops and were hollow to where the top had broken off. We could not determine if the top was hollow in the remaining 10 roost trees.

Table 1. Characteristics of 123 roost trees and 36 nest trees used by pileated woodpeckers in northeastern Oregon, 1989–90.

Variable	Roost tree $\bar{x}$	Roost tree SE	Nest tree $\bar{x}$	Nest tree SE
Tree dbh (cm)	70.6[a]	0.4	80.0	0.8
Tree height (m)	22.3	0.3	25.2	0.5
Hole height (m)	12.2	0.1	13.2	0.4
No. entrance holes	2.7[b]	0.1	2.1	0.2

[a] Nest and roost tree means differed (t = 2.88, 158 df, $P < 0.01$); t-test.
[b] Nest and roost tree means differed (t = −2.01, 158 df, $P < 0.05$); t-test.

The inside of the hollow chamber in the roost trees averaged 28 cm (SE = 0.29) in diameter and 4.3 m (SE = 0.22) in length. The shell of wood surrounding the chamber averaged 8 cm (SE = 0.15) thick, and the entrance hole averaged 11.3 cm (SE = 0.13) high and 8.5 cm (SE = 0.08) wide. The outside diameter of the tree at the roost hole entrance averaged 50 cm (SE = 0.46).

Conks of Indian paint fungus were seen on 92% of the roost trees in grand fir. Conks of this decay are perennial and are reliable indicators of the presence of advanced decay (Filip and Schmitt 1990).

Of the live trees used as roosts, 80% had some type of injury above the roost hole. Of the trees with injuries, 39% had new leaders rising from an obvious dead or broken top, 34% had a definite abrupt jog in the trunk where a new leader had grown >20 years ago (based on approximate number of branch whirls), 17% had a forked top, 15% had a dead top, and 2% had been hit by lightning. Sixty-seven percent had frost cracks or other basal injury.

Roost Tree Habitat

Roost trees were surrounded predominantly by old-growth stands of grand fir that had little or no logging. Eighty-eight percent of the roosts were in grand fir stands, 72% were in old-growth

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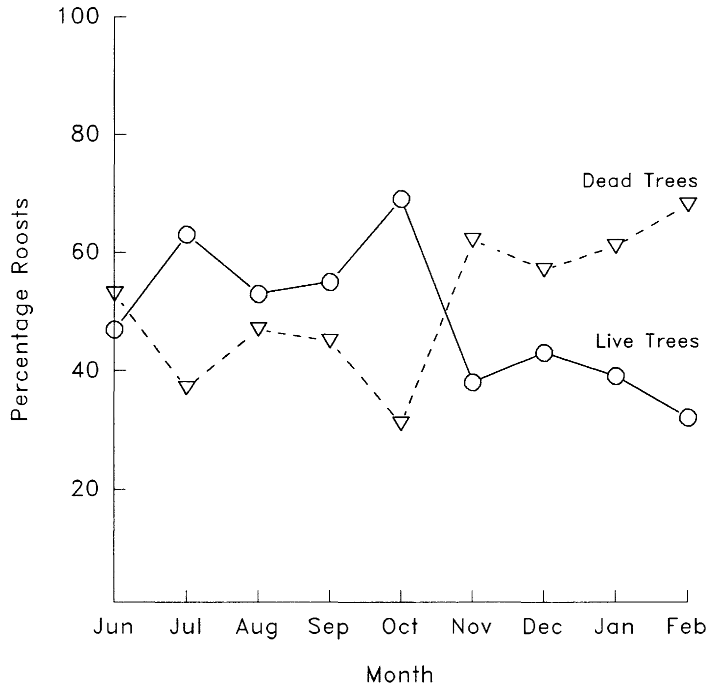

Fig. 1. Percentage of roosts in live and dead trees used by pileated woodpeckers in northeastern Oregon, 1989–90.

stands, 73% were in stands with ≥60% canopy closure, and 82% were in stands that were unlogged or had been high-graded.

The forest type and successional stage surrounding roost trees differed from random selection in all 5 study areas (forest type: χ^2 = 16.56, 244.17, 10.86, 11.97, 30.99; successional stage: χ^2 = 77.98, 119.17, 17.26, 29.19, 96.86; 1 df; all $P < 0.01$). Grand fir and old growth were used in higher proportions than expected. Logging activity differed between roosts and available habitat in 3 of the study areas (χ^2 = 27.60, 84.0, 18.44; 1 df; all $P < 0.01$); unlogged or high-graded stands were favored over those with partial overstory removals or shelterwood cuts. In the other 2 areas, so little logging activity had occurred that an analysis was not valid; all the roosts were in unlogged or high-graded stands. Canopy closure at roosts differed from random selection in 3 of the 5 study areas (χ^2 = 6.98, 13.85, 12.85; 1 df; all $P < 0.01$); denser canopy closures were favored. The mean canopy closure at roosts was 62.5% (SE = 0.32).

Roost trees were on the upper third of slopes 43% of the time, on the middle third of slopes 30% of the time, and on the lower third of slopes 27% of the time. Use of roosts at different positions on slopes changed over the year. For 15 birds that we followed in summer and winter, 9 used roosts higher on the slope from November to March than they did from June to October; the other 6 birds showed no change in use of roosts in relation to position on slope. For these 9 birds, trees lower on the slopes in their territories comprised 67% of their roosts from June to October but comprised only 19% of their roosts after November. We also noticed that the birds roosted more in dead trees after 1 November (Fig. 1).

Comparison of Nest and Roost Trees

Pileated woodpeckers nested in a different type of tree than they used for roosting. Of 36 nest trees located within the 5 study areas, all were in dead trees, and the species composition was 81% ponderosa pine, 11% western larch, and 8% grand fir. Tree species, condition, dbh, and number of entrance holes differed between nest and roost trees (χ^2 = 45.23, 2 df, $P < 0.01$; χ^2 = 28.20, 1 df, $P < 0.01$; t = 2.88, 158 df, $P < 0.01$; t = −2.01, 158 df, $P < 0.05$; respectively). Nest trees were larger and had fewer entrances than did roost trees (Table 1).

One striking difference between nests and roosts was that roost trees were hollow, and nest

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trees were solid wood. In 43 nest cavities, 81% had incipient or no decay, and the remainder had advanced decay (Bull 1987). Typically each pair of birds excavated a new nest cavity each year, although 3 of the 36 nest cavities used had been excavated in a previous year. Half the nest trees were climbed and not one was hollow.

Nest and roost trees differed in slope position ($\chi^2 = 13.78$, 2 df, $P < 0.01$) and in forest type ($\chi^2 = 21.61$, 2 df, $P < 0.01$) between nest and roost trees. The majority (75%) of nest trees were on the upper third of slopes, but only 43% of the roost trees were in this position. Almost all (93%) roost trees occurred in the grand fir forest type; whereas 67% of the nest trees occurred there. Thirty percent of the nest trees were in the Douglas-fir type and 3% in the ponderosa pine type. Successional stage, logging activity, or canopy closure did not differ ($P > 0.05$) between nest and roost sites.

Distribution of Roost Trees

Pairs of pileated woodpeckers showed a variety of distribution patterns in their use of roost trees. Of 12 individual birds (mates killed) or pairs followed for 3–9 months, 7 used 4–7 roost areas, 3 used 2–3 roost areas, and 1 used only 1 roost area. A roost area was defined as a single tree or a cluster of roost trees within a circle 0.4 km in diameter. Roost trees within 0.4 km were typically in the same stand, whereas those farther away were usually part of a different stand.

There was an average of 4 roost areas/territory with an average of 2–3 roost trees/area (range = 1–7). The average distance between adjacent roost areas within a territory was 0.8 km. The distance between the 2 most distal roosts in a territory averaged 1.8 km (SE = 0.33) but varied from 0.3 to 5.3 km.

Juvenile Use of Roost Trees

We recorded roosting behavior of only 4 juveniles; radios on the other 5 failed. Juveniles took 2–5 weeks to find roost cavities, and if chased from a cavity, did not have alternate roosts. Large-diameter, live trees were typically used as outside roost sites until cavities were located.

One juvenile female was located 23, 25, 30, and 33 days after she fledged, and she was roosting on the side of a tree each night. She was killed by a great horned owl (*Bubo virginianus*) (determined from prey remains) within 4 days of our last observation. A male juvenile was observed roosting on the side of a live ponderosa pine 12 days after he fledged but was roosting in a chamber in a dead western larch 5 days later. Two juvenile female siblings were roosting inside 2 dead ponderosa pine trees within 100 m of each other 24 days after they fledged. One of the juveniles was frightened out of the roost tree, flew about 1 km, and roosted on the side of a live Douglas-fir. We trapped both females several evenings later in the same dead ponderosa pines to replace their transmitters; subsequently, they stopped using the trees. Two days later, 1 female was roosting inside a dead grand fir, and the other was roosting on the outside of a dead Douglas-fir.

Juveniles roosted on the outside of trees that were all >50 cm dbh, and 6 of the 7 trees were live. The 4 trees where inside roosting was observed were dead, highly decayed, and averaged 76 cm dbh (SE = 2.79).

Roost Tree Formula

We have developed a formula to determine the number of trees to leave as roosts within each 243-ha U.S. Forest Service pileated woodpecker management area using the following rationale. Individual birds used up to 11 roosts in 3–10 months; so we began with 11 roosts needed/bird or 22/pair (and territory). We believe we found only half the roosts because we located birds in roosts only once every 2 weeks; so we estimated 44 roost trees/territory were really needed. We assumed there would be enough roosts for juveniles and floaters (nonbreeding birds within territory) if we used the maximum number (11) of roosts. We did not use the minimum or mean number of roosts because some birds with fewer roosts were killed; in addition, we would have had to add additional roosts for juveniles and floaters, and the resultant figure would be near 44. We think that if roosts are inadequate or the habitat around them marginal, mortality will increase.

We used coefficients of 0.25 and 0.05 for large-diameter, decayed grand fir with and without top injuries. respectively, because this is the best estimate we have at this time for how many trees will have hollow chambers (1 in 4 vs. 1 in 20). We estimated that 1 in 5 seemingly hollow ponderosa pine or western larch would be suitable roost trees. These coefficients may change

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if research shows other percentages are more appropriate. The number of trees in each category then can be calculated with the following formula:

$$44 = x_1 + (0.25)\,x_2 + (0.05)x_3 + (0.2)x_4$$

where x_1 = the number of actual hollow roost trees with pileated woodpecker cavities; x_2 = the number of grand fir (live or dead) >50–60 cm dbh, >15 m tall, with Indian paint fungus conks, and with an old injury (>20 years) above 10 m; x_3 = the number of grand fir >50–60 cm dbh, >15 m tall, with conks but no injury; and x_4 = the number of ponderosa pine or western larch (live or dead) that are hollow.

With this formula, any combination of these variables can be used to determine the number of trees to leave in each category. For example, if only large-diameter live grand fir with conks and no top injuries were left, 880 would be needed in each 243-ha management area. If large-diameter live grand fir with conks and old top injuries were left, 176 would be needed in each 243-ha management area. If only known roost trees were left, 44 would be needed; however, this information usually can be determined only with radio-tagged birds. Priority should be given to those trees having the greatest likelihood of use (known roosts and grand fir with decay and old injuries to the top).

DISCUSSION

We suspect pileated woodpeckers roosted in cavities all year to reduce predation and to conserve energy by minimizing heat loss in the winter. There was considerable predation on the woodpeckers we studied; at least 4 of the 9 radio-tagged juveniles were killed within 4 months. Of the 27 radio-tagged adults, only 56% survived 10 months. The other birds were killed by avian predators including northern goshawks (*Accipiter gentilis*), red-tailed hawks (*Buteo jamaicensis*), and great horned owls, based on evidence from prey remains. In addition, 2 transmitters were retrieved under active northern goshawk nests, and a red-tailed hawk was seen carrying a dead, previously radio-marked pileated woodpecker. Large, live trees may be important to the survival of juveniles (until they find cavities) because the juveniles produce less of a silhouette when perched on a large tree compared to a small tree.

The variety of roosts (4–11 roost trees in 3–10 months) used by individual adult birds allowed them to alternate sites if 1 tree fell over, if a predator was present near one, or if the roost was being used. Roosts where birds were captured were rarely reused by the same bird, so we suspect if a bird encountered a predator at a roost the bird usually did not use that roost again. The birds were unpredictable in how long they would use a roost tree before switching to another. Use of roost trees was not arbitrary, however, and at dusk, the birds flew directly to their roost trees.

Roosts in various locations within the territory allowed the birds to change position on the slope, possibly reduce predation risks, reduce distance from foraging areas to roosts, and provide alternate roosts if a particular stand was disturbed. It appeared that birds roosting in only 1 or 2 areas did so because other roost trees were not available; that is, we did not find other roost trees within their home ranges during the course of following the birds.

Other species used these roost trees as well, and we suspect that pileateds probably stopped using them if they were occupied by bushytail woodrats (*Neotoma cinerea*), flying squirrels (*Glaucomys sabrinus*), red squirrels (*Tamiasciurus hudsonicus*), or Vaux's swifts (*Chaetura vauxi*). If pileateds heard us scratching on their roost tree at night, they often flew out in the dark. It would be difficult for a pileated to tell the difference between a woodrat entering the tree after dark and potential predators, such as a marten (*Martes americana*).

Hollow trees may have been used for roosting to conserve time and energy. It takes 3–6 weeks for a pair to excavate a nest cavity (Bull and Meslow 1988). If each pileated woodpecker had to excavate 11 roost cavities each year, it would have time for little else.

Vacated nest cavities were only occasionally used by pileateds as roosts; often they were unavailable because flying squirrels and red squirrels inhabited them. Nest trees also had only 1 entrance; whereas 94% of the roost trees had >1 way in and out. We think the single hole in nest trees didn't provide enough different avenues of escape if a predator entered the tree, thereby making them unattractive as roost trees. Nest cavities also may become unattractive because of heavy parasite burdens often associated with nesting cavities. Hollow roost trees were not used for nesting, perhaps because the dis-

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tance to the chamber bottom made it difficult for the young to be fed or for the young to climb out. Hollow roost trees also had numerous entrance holes that could allow predators to enter, thereby complicating defense of the nest.

Because many live grand fir were hollow, we suspect it was the preferred tree species for roosting. Indian paint fungus is prevalent in most stands of mature or old-growth grand fir (Filip and Schmitt 1990) and causes nearly 80% of the decay in old-growth grand fir in the Blue Mountains in eastern Oregon (Aho 1977). An old injury to the top of the roost tree may be the most common way that decay begins (P. Aho, Corvallis, Oreg., pers. commun.) because 80% of the roosts in live trees had an old injury above the roost hole.

Injury to the tree top probably would have to occur at least 20 years prior to use by pileated woodpeckers to create a hollow chamber (P. Aho, Corvallis, pers. commun.). Aho (1974) cut >1,000 grand fir and recorded injuries to the tree, conks, and decay. Although he did not report on hollow chambers, Aho (pers. commun.) speculated that <5% of grand fir 50–75 cm dbh, with conks and no top injury, would have a hollow chamber; whereas 25–50% of grand fir 50–75 cm dbh, with conks and with an old injury, would be hollow.

Birds probably used the large-diameter trees because the hollow interiors were large enough ($\bar{x}$ = 28-cm inside diam.) for them to enter and maneuver. In addition, grand fir <25 cm dbh usually do not have active decay, and when infected, would require many years for the decay to create a hollow chamber large enough for a pileated woodpecker to use (A. Partridge, Univ. of Ida. Moscow, pers. commun.). No other conifer species in northeastern Oregon develops such widespread and extensive decay when alive.

Old-growth grand fir stands with ≥60% canopy closure and with little or no logging were preferred sites for roosts because these stands contained trees large enough, and with the appropriate decay, for roost trees. Even-aged forest management practices in use today (clearcut, shelterwood, overstory removal, final removal, etc.) remove trees that would be used for roosting and reduce the canopy closure. A closed canopy reduces heat loss in a stand at night (Daubenmire 1968:199) and probably provides protection from avian predators.

Pileated woodpeckers may have roosted higher on the slope and used more dead trees in winter, and vice versa in summer, because the draws were cooler in summer and the upper slopes warmer in winter. Ponderosa pine occurs primarily on the mid- to upper slopes in the Blue Mountains (Johnson and Simon 1987), and all the pines used as roost trees were dead trees. Therefore, if the birds wanted to roost higher on the slope, there was often a higher percentage of dead ponderosa pine available there than lower on the slope.

MANAGEMENT IMPLICATIONS

Current Forest Service plans call for managing 243-ha areas for pileated woodpeckers. Requirements for these areas are designed to provide nesting (121.5 ha) and foraging habitat (121.5 ha). Roosting habitat was not considered. To provide roosting habitat under the existing conditions in northeastern Oregon, we recommend leaving old-growth stands of grand fir with ≥60% canopy closure with no logging or high-grading of old trees. Within these stands, there should be an abundance (>10/ha) of grand fir >50 cm dbh, both live and dead. We also recommend that biologists and managers use our roost tree formula to determine the number of trees to leave as roosts within each 243-ha pileated woodpecker management area.

We recommend that roost trees be distributed among at least 4 old-growth stands for roost areas (at least 0.5 km apart) and at various slope locations (if available) in each 243-ha management area. At least 1 of these stands should be on the upper third of the slope and should contain a combination of large-diameter dead ponderosa pine (if pine occurs in the area) and live or dead grand fir for use in the winter. The size of each area will depend on the number of potential roost trees left in each area.

According to National Forest Plans, half of each management area will be managed as nesting habitat and will be mature and old-growth forest. There should be little difficulty maintaining roost trees in these areas. Roost trees are, however, typically scattered throughout the territory, so management for roost trees also should be maintained in foraging areas.

Roost trees are unique and uncommon and need to be left and protected where they occur. In addition, roost trees need to be maintained over time, so plans for future stands with po-

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tential roost trees and appropriate habitat conditions need to be developed and implemented.

LITERATURE CITED

AHO, P. E. 1974. Defect estimation for grand fir in the Blue Mountains of Oregon and Washington. U.S. For. Serv. Res. Pap. PNW-175. 12pp.

———. 1977. Decay of grand fir in the Blue Mountains of Oregon and Washington. U.S. For. Serv., PNW For. Range Exp. Stn., Res. Pap. PNW-229. 18pp.

BULL, E. L. 1987. Ecology of the pileated woodpecker in northeastern Oregon. J. Wildl. Manage. 51:472–481.

———, M. G. HENJUM, AND R. S. ROHWEDER. 1988. Nesting and foraging habitat of great gray owls. J. Raptor Res. 22:107–115.

———, R. S. HOLTHAUSEN, AND M. G. HENJUM. 1990. Techniques for monitoring pileated woodpeckers. U.S. For. Serv., PNW-GTR-269. 13pp.

———, AND E. C. MESLOW. 1988. Breeding biology of the pileated woodpecker—management implications. U.S. For. Serv., PNW-RN-474. 8pp.

BURR, J. A. 1960. Soil survey, Starkey Experimental Forest and Range, Union and Umatilla counties, Oregon. U.S. Dep. Agric. Soil Conserv. Serv. and For. Serv. 32pp.

CONNER, R. N., R. G. HOOPER, H. S. CRAWFORD, AND H. S. MOSBY. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39:144–150.

CONOVER, W. J. 1980. Practical nonparametric statistics. Second ed. John Wiley and Sons, New York, N.Y. 493pp.

DAUBENMIRE, R. 1968. Plant communities: a textbook of plant synecology. Harper and Row, New York, N.Y. 300pp.

FILIP, G. M., AND C. L. SCHMITT. 1990. Rx for *Abies*: silvicultural options for diseased firs in Oregon and Washington. U.S. For. Serv., PNW-GTR-252. 34pp.

HOYT, S. F. 1957. The ecology of the pileated woodpecker. Ecology 38:246–256.

JOHNSON, C. G., JR., AND S. A. SIMON. 1987. Plant associations of the Wallowa-Snake province. U.S. For. Serv., R6-ECOL-TP-255A-86. 400pp.

KILHAM, L. 1979. Courtship and the pair-bond of pileated woodpeckers. Auk 96:587–594.

LAWRENCE, L. D. K. 1970. The apartment. Audubon 72:4–7.

MCCLELLAND, B. R. 1977. Relationships between hole-nesting birds, forest snags, and decay in western larch–Douglas-fir forests of the northern Rocky Mountains. Ph.D. Thesis, Univ. Montana, Missoula. 496pp.

MELLEN, T. K. 1987. Home range and habitat use by pileated woodpeckers, Western Oregon. M.S. Thesis, Oregon State Univ., Corvallis. 96pp.

STRICKLER, G. S. 1959. Use of the densiometer to estimate density of forest canopy on permanent sample plots. U.S. For. Serv., RN PNW-180. 5pp.

THOMAS, J. W., R. G. ANDERSON, C. MASER, AND E. L. BULL. 1979. Snags. Pages 60-77 *in* J. W. Thomas, ed. Wildlife habitats in managed forests—the Blue Mountains of Oregon and Washington. U.S. Dep. Agric. Handb. 553.

WELLNER, C. A. 1978. Effects of past events. Pages 185-189 *in* M. H. Brookes, R. W. Stark, and R. W. Campbell, eds. The Douglas-fir tussock moth: a synthesis. U.S. For. Serv., Tech. Bull. 1585.

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